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# 18. Почему тёмная луна нам кажется ярко-серебристой, а белые облака выглядят чёрными?

6-8 minutes

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When discussing the color of the moon, a question always arises that baffles many: why does a dark moon seem bright silver to us?

The moon - everyone already knows this - the object is very dark, with a low reflectivity. On the moon there are light surfaces - continents, with a reflection coefficient of 12-15%, there are dark surfaces - seas that reflect 7-8% of the incident light or less. On the ground, such objects look approximately like a dark brown cabinet in lightness. Lunar "seas" have a low reflectance due to the relatively high amount of iron oxide (FeO), a very dark substance.

Iron oxide, FeO

It is likely that it is iron oxide that gives the seas a dark hue.

This is how the Moon looks up close.

But on the other hand, the moon appears bright white in the night sky. And in a telescope in general, it is perceived as dazzlingly bright.

Why, then, do we see the dark moon bright silver at night?

Moon at night.

The answer is quite simple: for the same reason that white clouds appear black to us - because of the background onto which they are projected.

On a sunny day, the top of the cloud looks bright white, but the surface facing the ground is perceived as dark gray due to the fact that it is less illuminated. In the center of the next photo, we see two dark gray clouds against a large white background.

Clouds on a sunny day.

They are not illuminated by the sun, they are in the shadow of a large cloud, but they are exactly the same WHITE clouds. As soon as these clouds come out of the shadows, they will become bright white for us again. But they seem to us dark now simply because they are projected onto a brighter background. If the background is even brighter or if the clouds are in a strong shadow, then they will seem to us not just gray, but already black. We often see such a "picture" at sunset. And it doesn't surprise us at all that perfectly white clouds look black.


Clouds at sunset.

And here's what's interesting. When the sun sets below the horizon, the sky on the west side is still light, and on the opposite, east side, it has already become dark. If at this time a large strip of clouds passes through the sky, then the part that is projected onto a bright sunset will appear black, silhouette, and the other part of the clouds on the east side will still remain white IN THE BACKGROUND OF THE DARK SKY.

In other words, whether an object is perceived as light or dark depends on the background onto which it is projected.

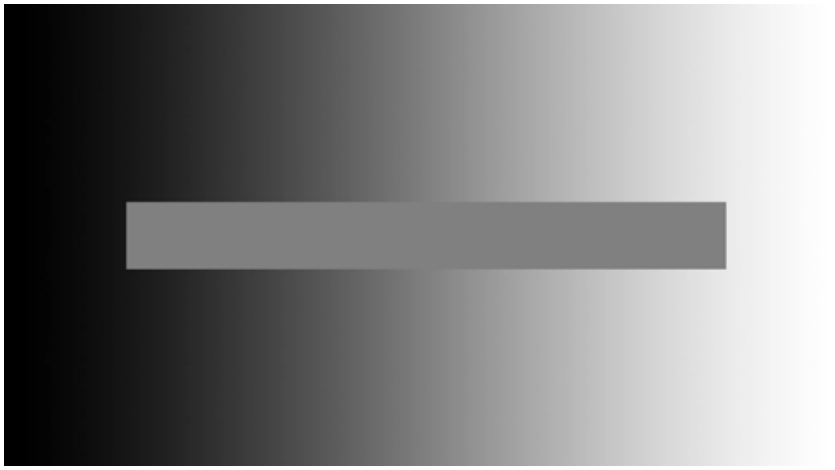
There is such a visual illusion: a uniform gray stripe is projected onto a "gradient" background (the background changes from black to white).

The left side of the strip, which is projected onto a dark background, seems to us lighter, while the right side of the strip on a light background, on the contrary, becomes darker and darker towards the edge.

This is a subjective perception, we can say that it is a common visual illusion caused by the work of the external geniculate bodies in the human eye. This property of our perception is called - the phenomenon of simultaneous contrast.

The phenomenon of simultaneous contrast.

This is how this simultaneous contrast phenomenon looks in motion (GIF).



Effect of the background on the perceived brightness of the gray bar.

Brightness for a person is a subjective, relative concept. Depends on the environment. For the same object, we can say that it is white and immediately call it black.

For example, we have white walls and a white ceiling in our room. And on one of the walls we project an image from a slide projector.

The image is projected onto a white wall. (Photo from the Internet.)

We have no doubt that the wall is white. At the bottom left of the frame is a black speaker. And now we transfer our eyes to the picture. The picture is bright. We see white snow. It is brighter than the white wall in the room. We see black shadow sections of the Kremlin wall. But the black object in the image is a section of the white wall not illuminated by the projector. This dark area of the picture on the screen is illuminated only by the light diffused in the room. If we take a brightness meter and measure this area with an objective device, it will show that the shadow (almost black) part of the Kremlin wall and the white wall in our room are the same brightness. But in the first case, we subjectively take the wall under the screen for white, and in the other case, we perceive exactly the same brightness (the shadow part of the Kremlin wall) as black. And all because our "black"

To get a psychologically high-quality picture on a movie screen, it is quite enough that the brightest object (for example, snow) is 20 times brighter than the surrounding background. Then a bright object will seem white to us, and something that is 20 times less in brightness will already be perceived as "black".

Now, when you come to watch a movie in a cinema, you'll probably think: "This is a white screen. Until the movie starts, it seems white to us, because there are darker objects next to it (a black velvet strip around the screen). And now we began to consider the place highlighted by the projector as "white", and the part of the screen where the light did not hit (the actor's dark clothes, the dark tree trunk) became a "black" area for us. " At this point, the white screen became black in our perception.

**And now, I think, it is already quite easy to understand why the moon seems to us "silvery". There is no white sheet of paper next to the moon in the sky, relative to which we would understand that the moon is dark. But there is night darkness, black background. And relative to this background, the moon appears almost white.**

Even during the day, the mainland part of the moon is about 3-4 times brighter than the blue sky. The difference is small, and the moon seems to us pale, low-contrast.

Moon in the daytime sky.

But now twilight comes. The sky begins to darken gradually. The difference in brightness between the moon and the sky is becoming more and more noticeable. When the sky is 20 times darker than the surface of the moon, the continents of the moon will appear white. And when it gets completely dark and the sky turns black, the difference will reach 7500 times (according to my measurements within the city). There will be a feeling that there, instead of the moon, in the black sky there is some kind of silver mirror that reflects the light. That is why the moon is called at this moment "bright silver".

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Cameraman L. Konovalov was with you.


Until next time!